

EPO - DG 1

01 07. 2004

(68)

TS 1195 PCTC L A I M S

1. A process for the preparation of normally liquid and normally solid hydrocarbons and the generation of heat by reaction of carbon monoxide and hydrogen in the presence of a catalyst at elevated temperature and pressure in at least two stages, the process comprising:
  - 5 i) introducing a gas comprising carbon monoxide and hydrogen into a first reactor section comprising catalyst and introducing Fischer-Tropsch liquid product cooling fluidum into this first reactor section;
  - 10 ii) allowing a part of the carbon monoxide and hydrogen to react catalytically in the first reactor section to hydrocarbons and water, at least part of the reaction heat being absorbed directly by the cooling fluidum;
  - 15 iii) withdrawing from the reactor section a stream consisting of the reaction product comprising the hydrocarbons, water, unconverted feed and cooling fluidum;
  - iv) cooling down at least part of the withdrawn stream comprising cooling fluidum to generate heat;
  - 20 v) optionally removing water from the withdrawn stream;
  - vi) introducing stream obtained in step v) comprising at least unconverted carbon monoxide and hydrogen into a second or further reactor section comprising catalyst and introducing Fischer-Tropsch liquid product cooling fluidum into this second or further reactor section;
  - 25 vii) optionally introducing a hydrogen containing stream into the second or further reactor section;

viii) allowing a part of the carbon monoxide and hydrogen to react catalytically in the second or further reactor section to hydrocarbons and water, at least part of the reaction heat being absorbed directly by the Fischer-Tropsch liquid product cooling fluidum;

ix) optionally repeating steps iii-viii in further reactor sections and

x) withdrawing from the last reactor section the reaction product comprising the hydrocarbons, water, any unconverted carbon monoxide, any unconverted hydrogen and Fischer-Tropsch liquid product cooling fluidum.

2. A process according to claim 1, in which the number of stages is between 5 and 20, preferably between 8 and 12.

3. A process according to claim 1 or 2, in which the CO conversion per stage is between 3 and 40 vol%, preferably between 6 and 15 vol% (conversion of CO based on feed stream to the first reactor section).

4. A process according to any of claim 1 to 3, in which the H<sub>2</sub>/CO ratio of the gas feed to the first stage is between 1.6 and 0.4, preferably between 1.1 and 0.5, especially a process in which additional hydrogen is introduced in the one or more stages following the first stage, preferably in such a way that the H<sub>2</sub>/CO ratio to the second and further stages is between 1.6 and 0.4, more preferably between 1.1 and 0.5.

5. A process according to any of claims 1 to 4, in which in the first reactor section, preferably all reactor sections, at least 50% of the heat generated by the reaction is directly absorbed by the cooling fluidum, preferably at least 90%.

6. A process according to claim 5, in which at least the first reactor section is an adiabatic reactor section,

preferably all reactor sections are adiabatic reactor sections.

7. A process according to any of claims 1 to 6, in which the temperature increase of the cooling fluid per reactor section is between 5 and 20 °C, preferably between 7 and 15 °C.

5 8. A process according to any of claims 1 to 7, in which GHSV of the carbon monoxide and hydrogen together is between 2000 and 20000 Nl/l/h, preferably between 3000 and 10000 Nl/l/h based on total catalyst volume  
10 (including voids).

15 9. A process according to any of claims 1 to 8, in which the volume ratio (STP) between the gas fraction and the cooling fluidum fraction introduced in each reactor section is between 0.5 and 2, preferably about 1.

20 10. A process according to any of claims 1 to 9, in which the catalyst comprises iron, cobalt or nickel on a carrier, especially cobalt, preferably in combination with one or more promoters selected from manganese and zirconium oxide or rhenium and platinum.

11. A process according to claim 10, in which the catalyst comprises a carrier in the form of a fixed bed, preferably a fixed bed having a void ratio between 50 and 85 vol%, preferably between 60 and 80 vol%.

25 12. A process according to claim 11, in which the fixed bed comprises one or more monolithic structures, preferably ceramic monolithic structures, metal extruded monolithes or carbon monolithes, layers of corrugated plates, especially metal corrugated plates, gauzes, especially metal gauzes or shavings, especially metal shavings.

30 13. A process according to any of claims 1 to 12, in which heat is exchanged to decrease the temperature of

the stream withdrawn from any reactor section by 5-20 °C, preferably 7-15 °C, more preferably by the temperature increase of the reactor section involved.

14. A process according to any of claims 1 to 13, in which the cooled down stream withdrawn from one or more reactor sections, preferably each second reactor sections, is separated into a liquid stream and a gaseous stream, followed by further cooling down the gaseous stream, suitably to a temperature between 80 and 150 °C, preferably to a temperature between 90 and 130 °C.

15. A process according to any of claims 1 to 14, in which water is removed from the process by separating water from the withdrawn stream from the reactor sections, preferably by separating water from the cooled down withdrawn streams or from the cooled down gas streams following condensation of water after cooling down or by membrane separation from the withdrawn streams.

16. A process according to any of claims 1 to 23, in which cooled down cooling fluidum from a reactor section is introduced into the same reactor section or in which cooled down cooling fluidum from a reactor section is introduced into the next reactor section.

17. A process according to any of the preceding claims, in which the temperature of the hydrocarbon synthesis reaction is between 170 and 320 °C, preferably between 190 and 270 °C, and the pressure is between 5 and 150 bar, preferably between 20 and 80 bar.

18. Reactor suitable for carrying out the process as described in any of the preceding claims.

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